Western Airborne Contaminants Assessment Project (WACAP)

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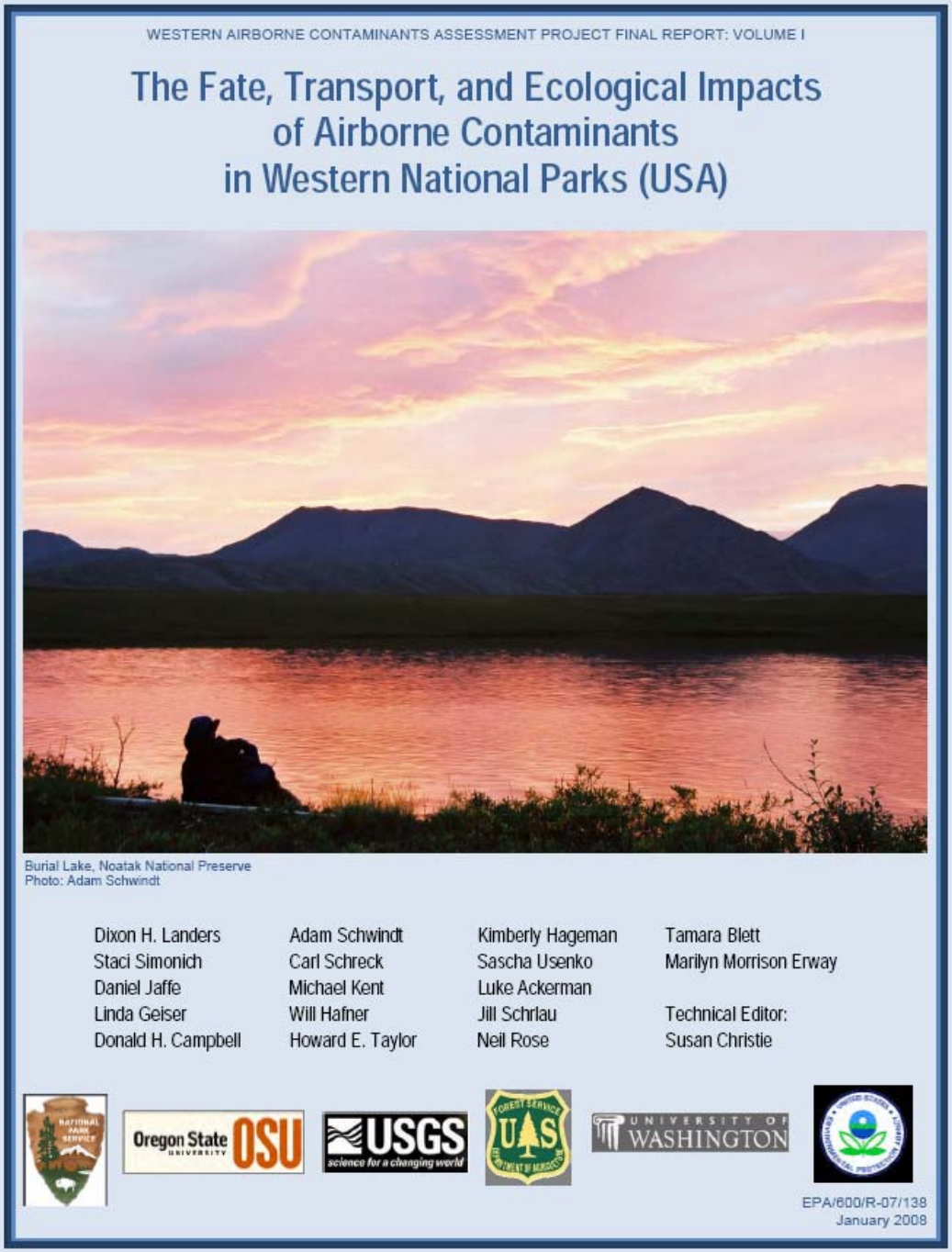
The Relationship between Mercury Deposition and Ecological Effects: WACAP Results in Snow, Sediment, and Fish

NADP – October 16, 2008
Colleen Flanagan, NPS Air Resources Division

Burial Lake, Noatak National Preserve
Photo: Adam Schwindt



NATIONAL PARK SERVICE

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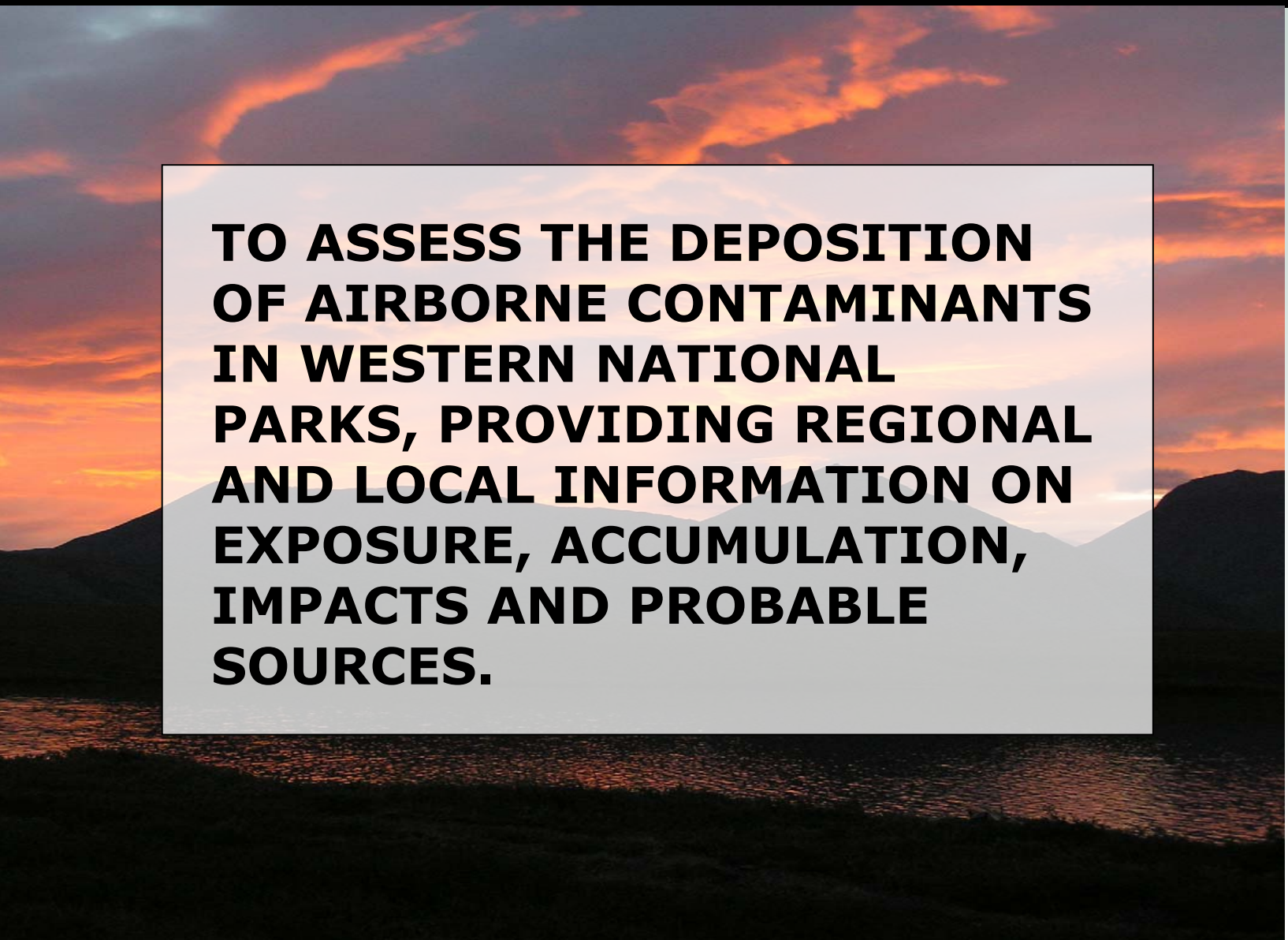
EPA/600/R-07/138.

U.S. Environmental Protection Agency, Office of Research and Development, NHEERL, Western Ecology Division, Corvallis, Oregon.

WACAP Goal



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TO ASSESS THE DEPOSITION OF AIRBORNE CONTAMINANTS IN WESTERN NATIONAL PARKS, PROVIDING REGIONAL AND LOCAL INFORMATION ON EXPOSURE, ACCUMULATION, IMPACTS AND PROBABLE SOURCES.

Key Scientific/Ecological Questions

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1.) **Are contaminants present in western National Parks?**

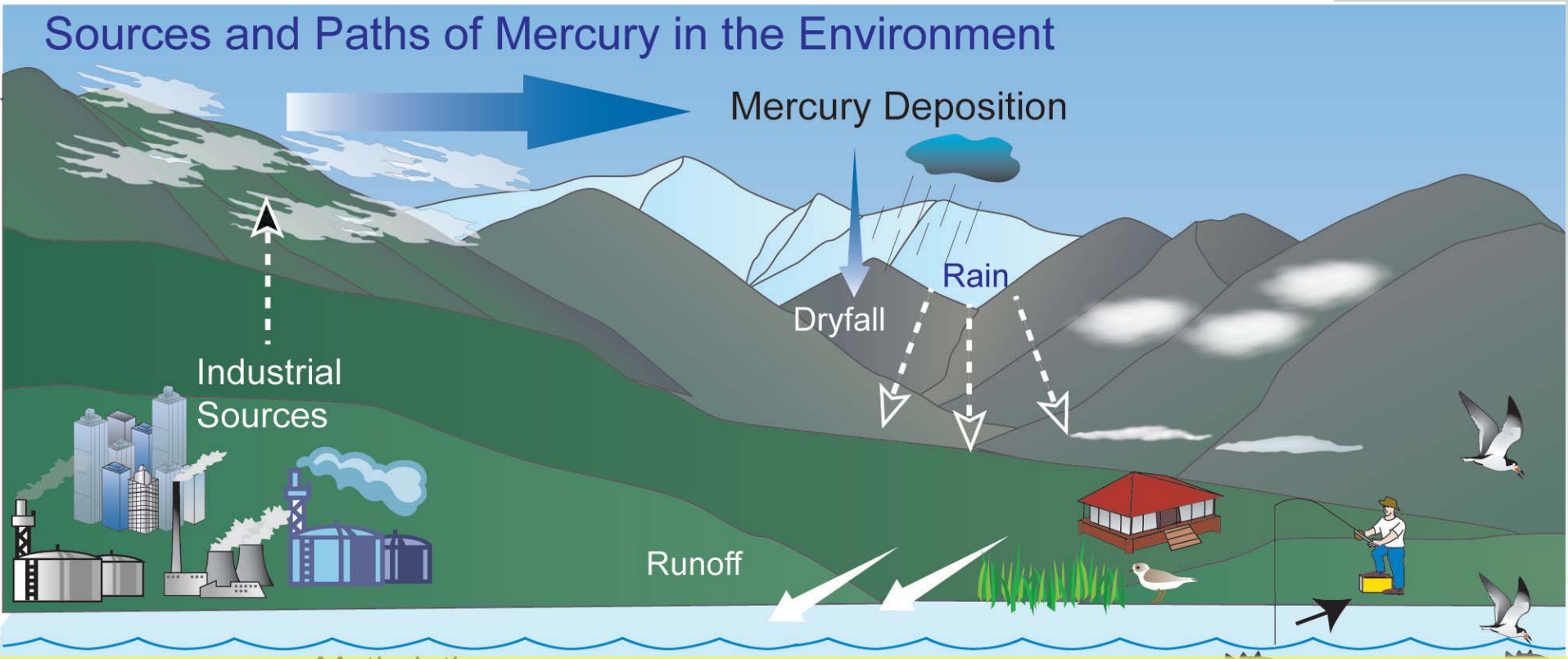
2.) **Where do contaminants accumulate (ecologically and geographically)?**

3.) **Which contaminants pose the greatest ecological threat?**

4.) **Which ecological *indicators* are the most useful in interpreting contamination?**

5.) **What are the probable sources of the air masses most likely to have transported contaminants to the National Park sites?**

Hg Deposition => Hg Effects



Mercury Deposition Conceptual Diagram, NPS, 2006

- **High dissolved sulfate, low lake water pH, and high organic carbon favor methyl-Hg accumulation in fish (Wiener et al., 2006); Lake temperature has also been implicated in methylation (Schindler et al., 1995; Lambertsson and Nilsson, 2006).**

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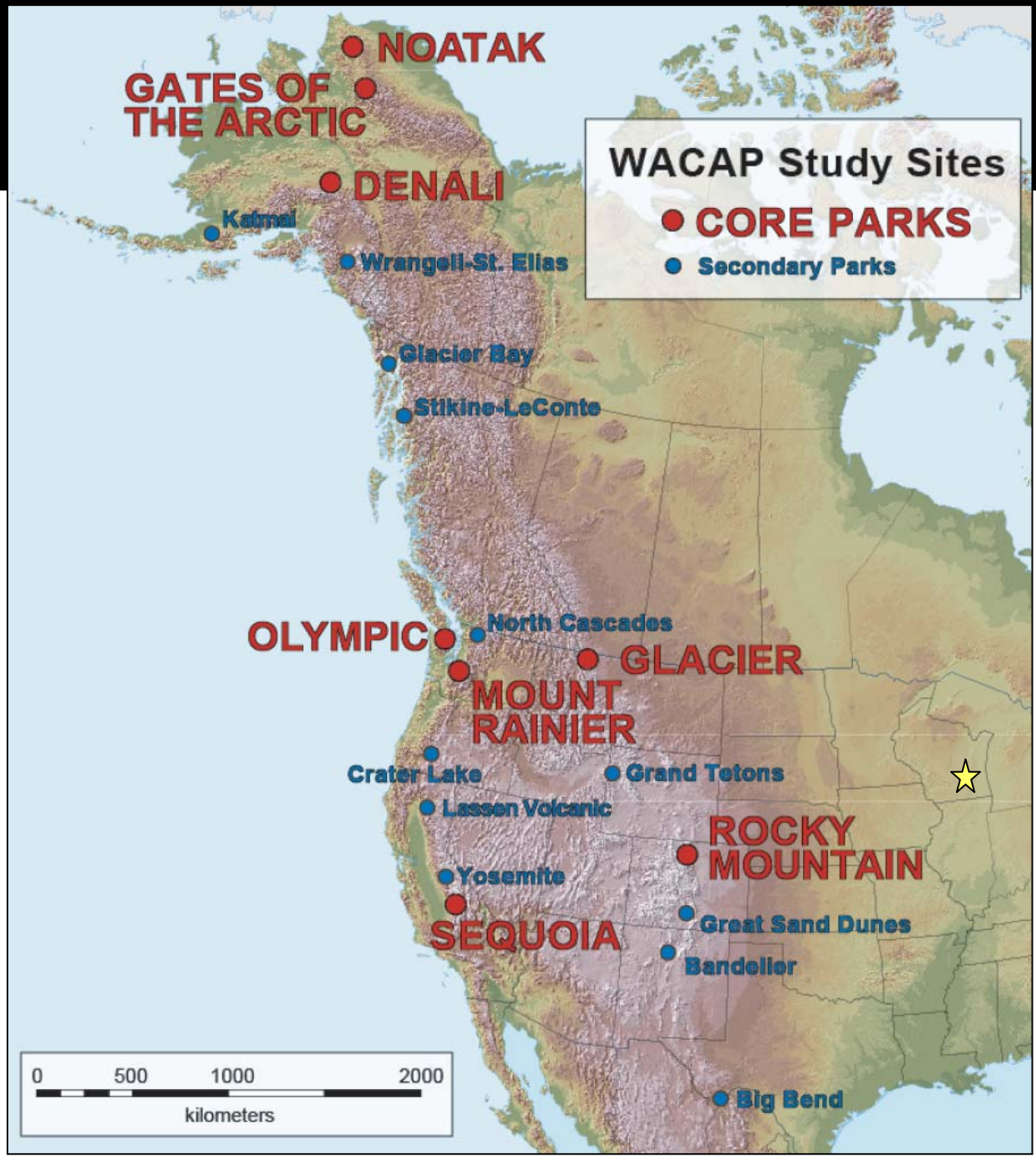
WACAP Indicators and Airborne Contaminant Assessment Approach

Sampling Locations

- 20 total
- 8 core sites included Hg analysis in snow, lake sediment, fish, and vegetation
- 12 secondary sites focused on vegetation



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Noatak= NOAT
Gates of the Arctic= GAAR
Denali= DENA
Glacier= GLAC
Olympic= OLYM
Mt Rainier= MORA
Sequoia= SEKI
Rocky Mountain= ROMO

Mercury in the Media

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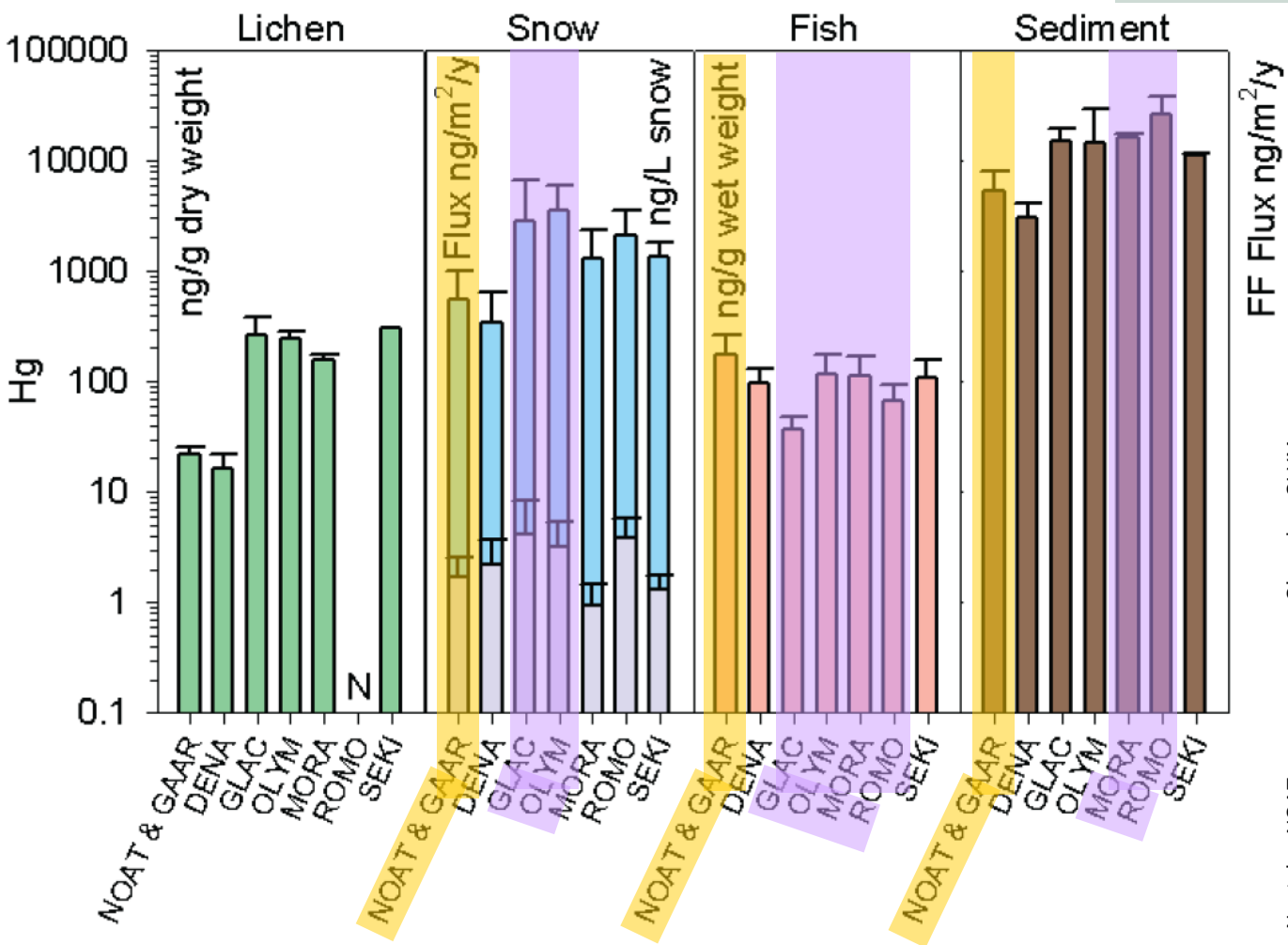
- Hg flux in snow greatest at Glacier and Olympic
- Hg flux in sediment highest at Mt Rainier and Rocky Mountain
- Hg ww in fish greatest in Arctic parks, but there is where flux is lowest



Snow Hg Fluxes

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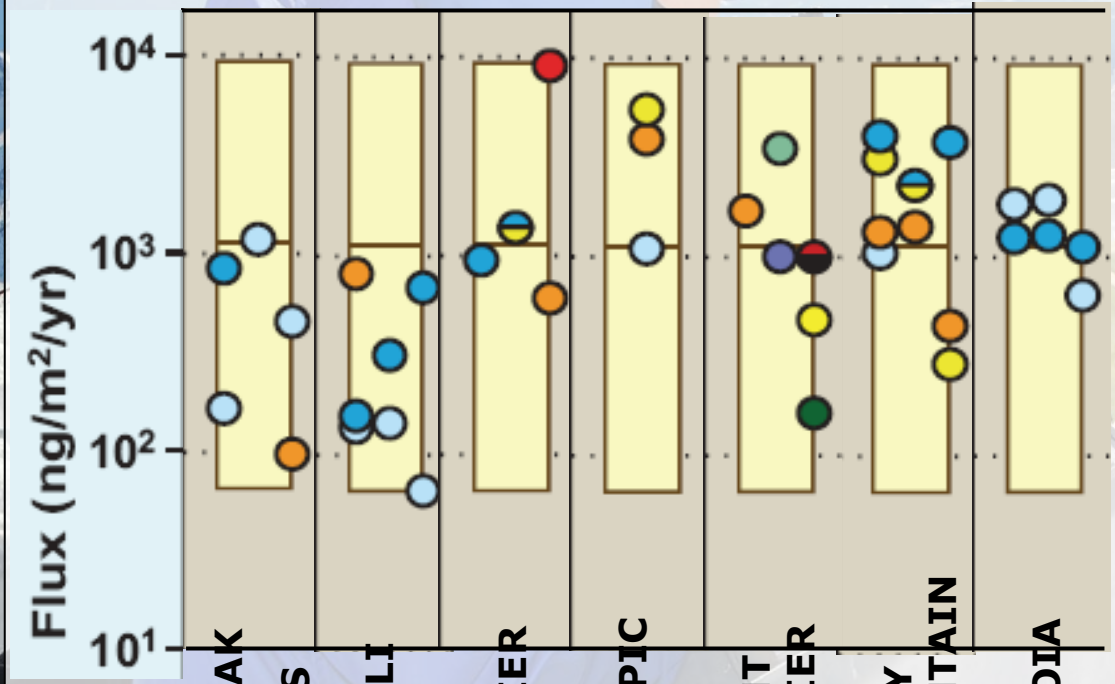

- Snow samples taken Spring 2003, 2004, 2005 (L to R)
- Range of values indicated by box; Median indicated by bar
- Deposition fluxes ranged from 336 ng/m^2/yr at Denali to 3600 ng/m^2/yr at Olympic

Hg Sediment Profiles

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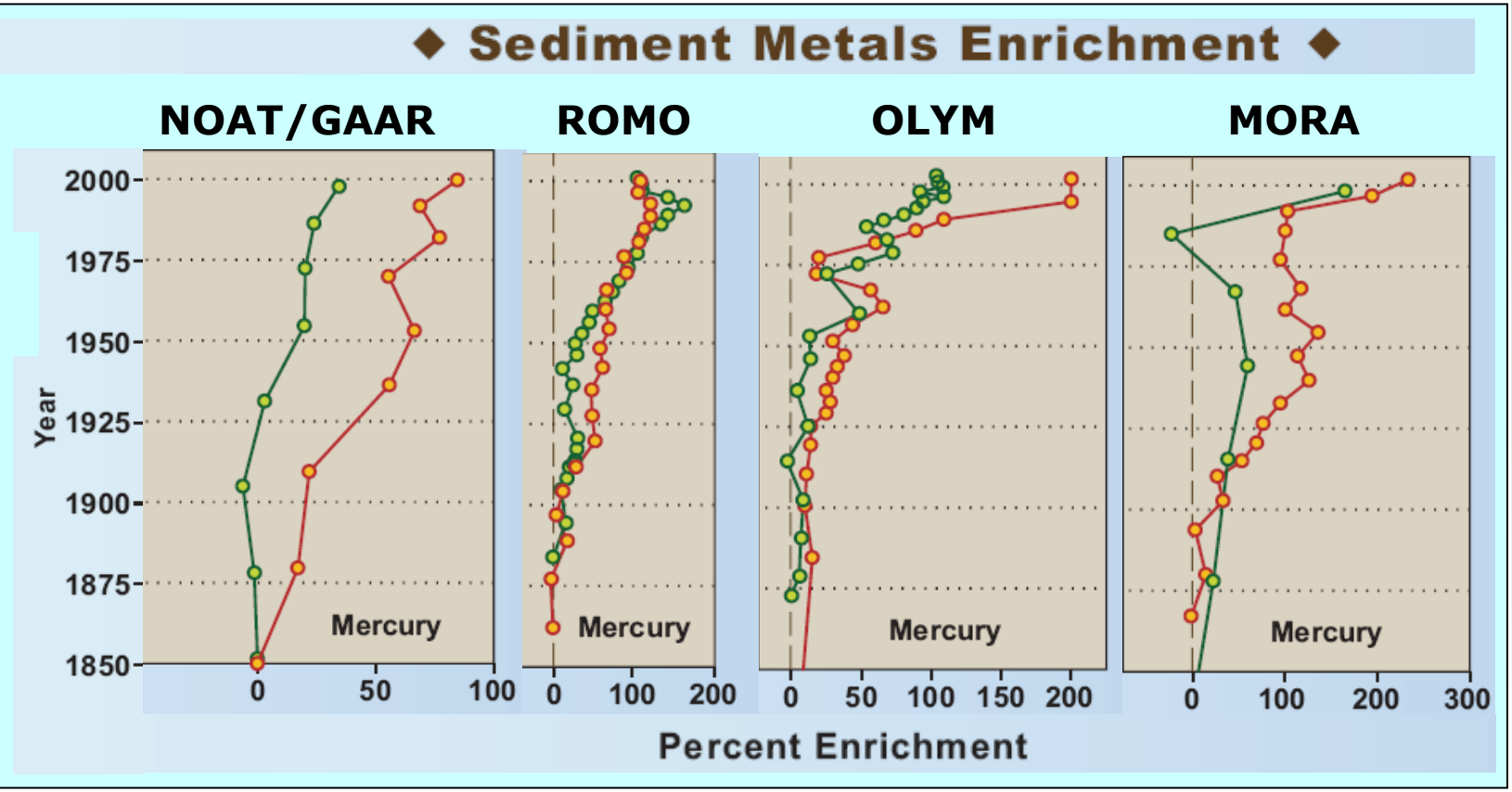

- Mercury profiles at the Arctic parks stabilize at relatively low percent enrichment values.
- Olympic, Mount Rainier, Rocky Mountain (also Glacier and Sequoia) show stabilization at fairly high percent enrichment values.

Noatak= NOAT
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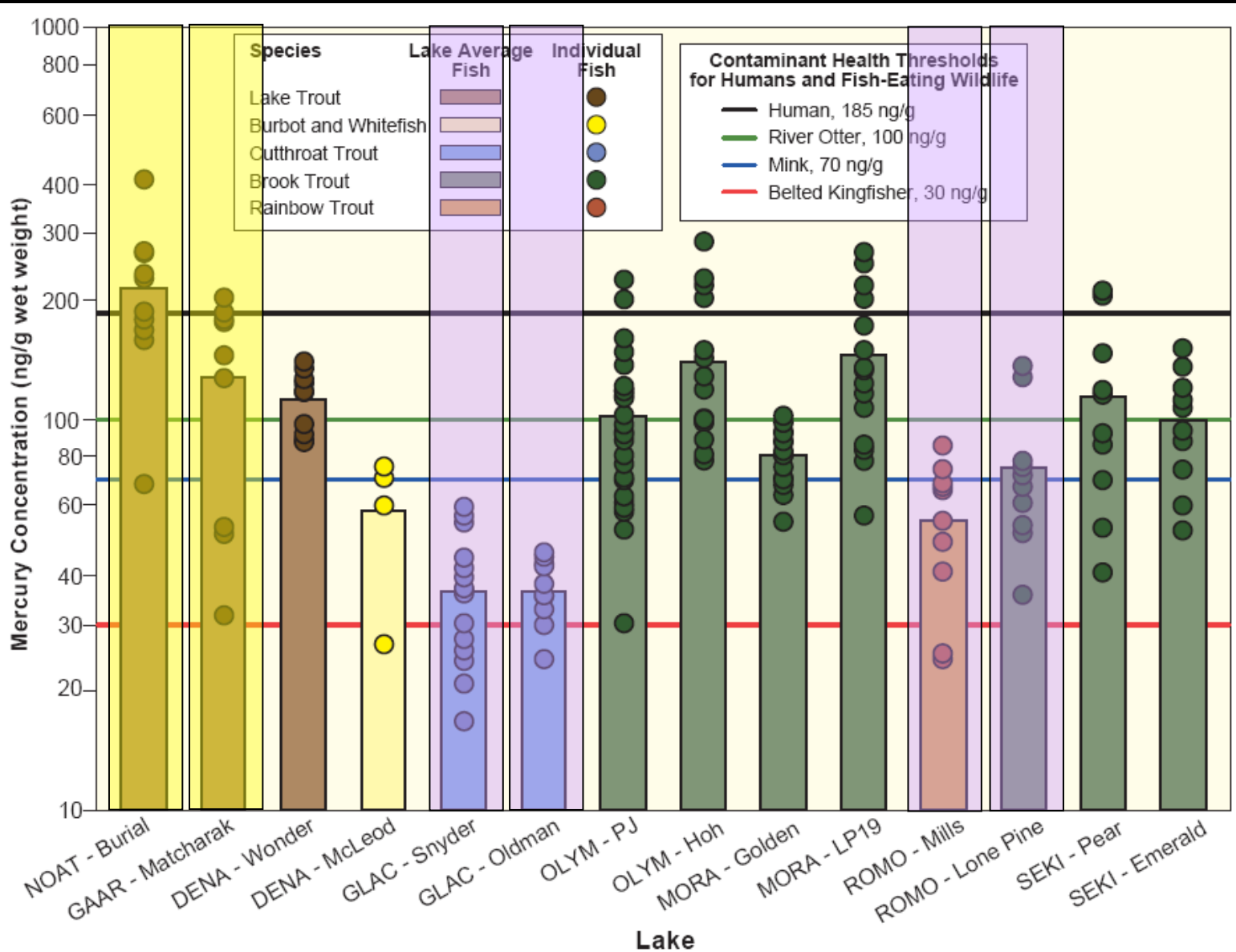
Hg in Fish: Health risks



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- 20 of 169 fish exceeded human health threshold
- Risk thresholds for health impacts to piscivorous birds and mammals also exceeded
- Toxic effects include neurological and reproductive impairment

High Hg_{tot} in Arctic parks?

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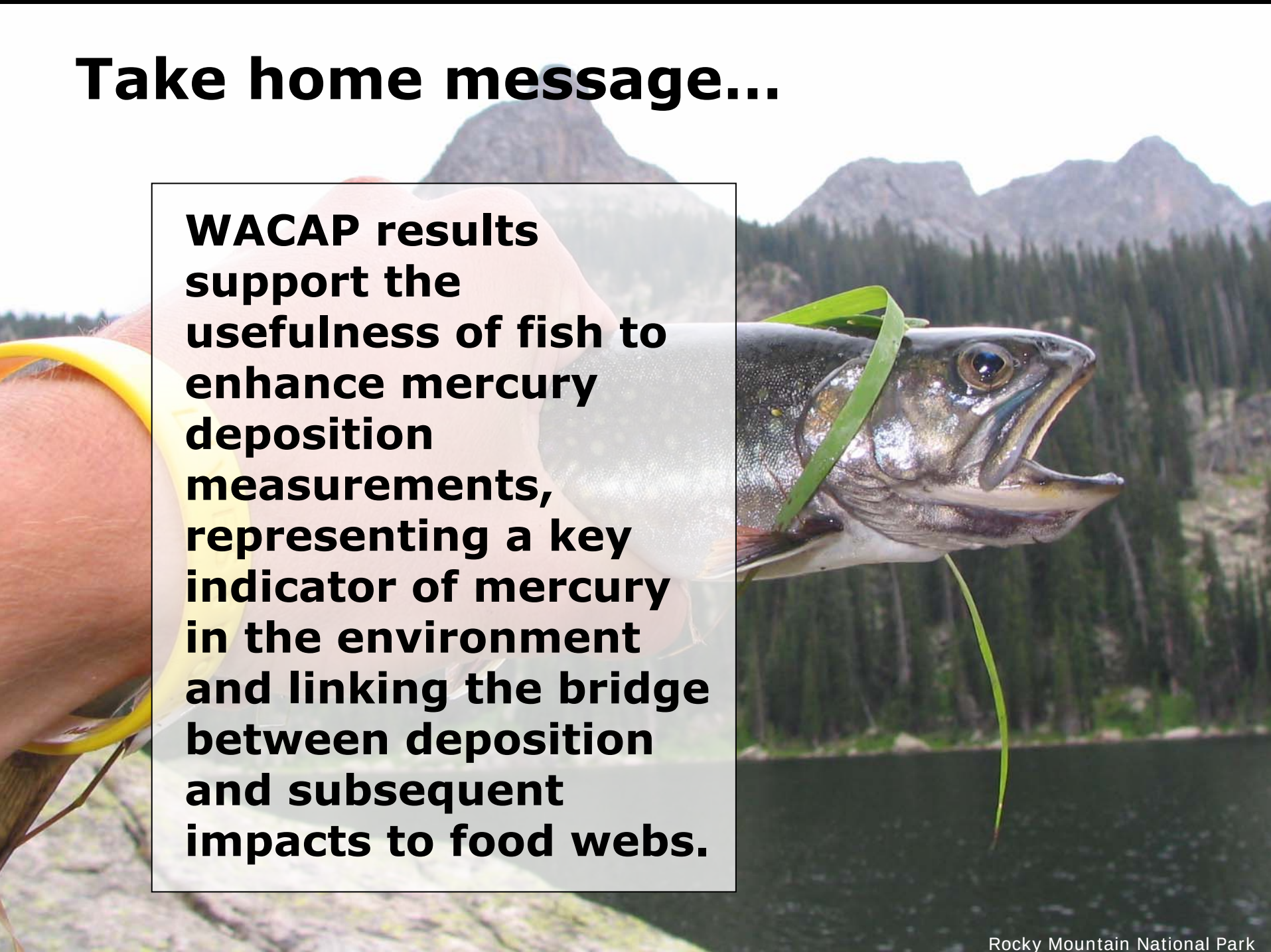
- Phosphorus?
  - Burial Lake approaches being mesotrophic with water column Ptot = 9 µg/L
  - However, several studies indicate that increased primary production can reduce the uptake of MeHg
- DOC?
  - Arctic lakes had the highest DOC of all WACAP lakes (Burial = 3.3 mg/L; Matcharak = 4.7 mg/L)
  - Suggests a greater connection to sources of DOC, known and likely sites of mercury methylation

Take home message…

WACAP results support the usefulness of fish to enhance mercury deposition measurements, representing a key indicator of mercury in the environment and linking the bridge between deposition and subsequent impacts to food webs.



Rocky Mountain National Park

Follow up Hg research areas

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- **Continue to assess Hg concentrations and impacts on fish**
- **Identify ecosystem variables in Alaska parks that result in higher bioaccumulation of mercury in fish**
- **Consider factors such as methylation processes and food web structure in study designs**
- **Measure selenium to explore ability to bind with methyl mercury in organisms**

- **Determine the extent to which local sources contribute to mercury deposition at MORA and ROMO**
- **Continue to monitor the deposition of mercury at OLYM, DENA, and NOAT in order to better track the relative contribution of global sources over time**
- **Determine the speciated components of mercury in the air, RGM and pHg, and what they tell us about regional mercury source contributions**

Other NPS Hg Studies

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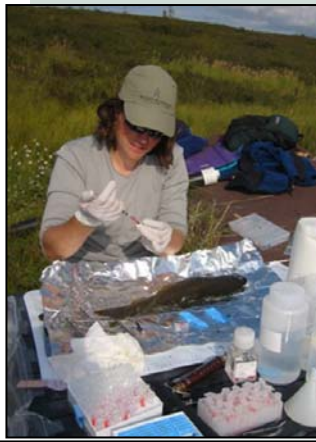
- Extensive research at Everglades, Acadia, Isle Royale, Voyageurs, Great Smoky Mountains
- Sediment coring at Rocky Mountain, Great Sand Dunes, Yosemite, Glacier
- Assessing the Impact of Mercury Bioaccumulation at Mammoth Cave, et al.
- Ecological Effects of Mercury Deposition in Mesa Verde National Park, Colorado



For More Information

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WACAP webpage

http://www.nature.nps.gov/air/Studies/air_toxics/wacap.cfm

NPS mercury webpage

http://www.nature.nps.gov/air/AQBasics/mercury.cfm

Sequoia & Kings Canyon National Parks
Photo: USGS

WACAP and MDN

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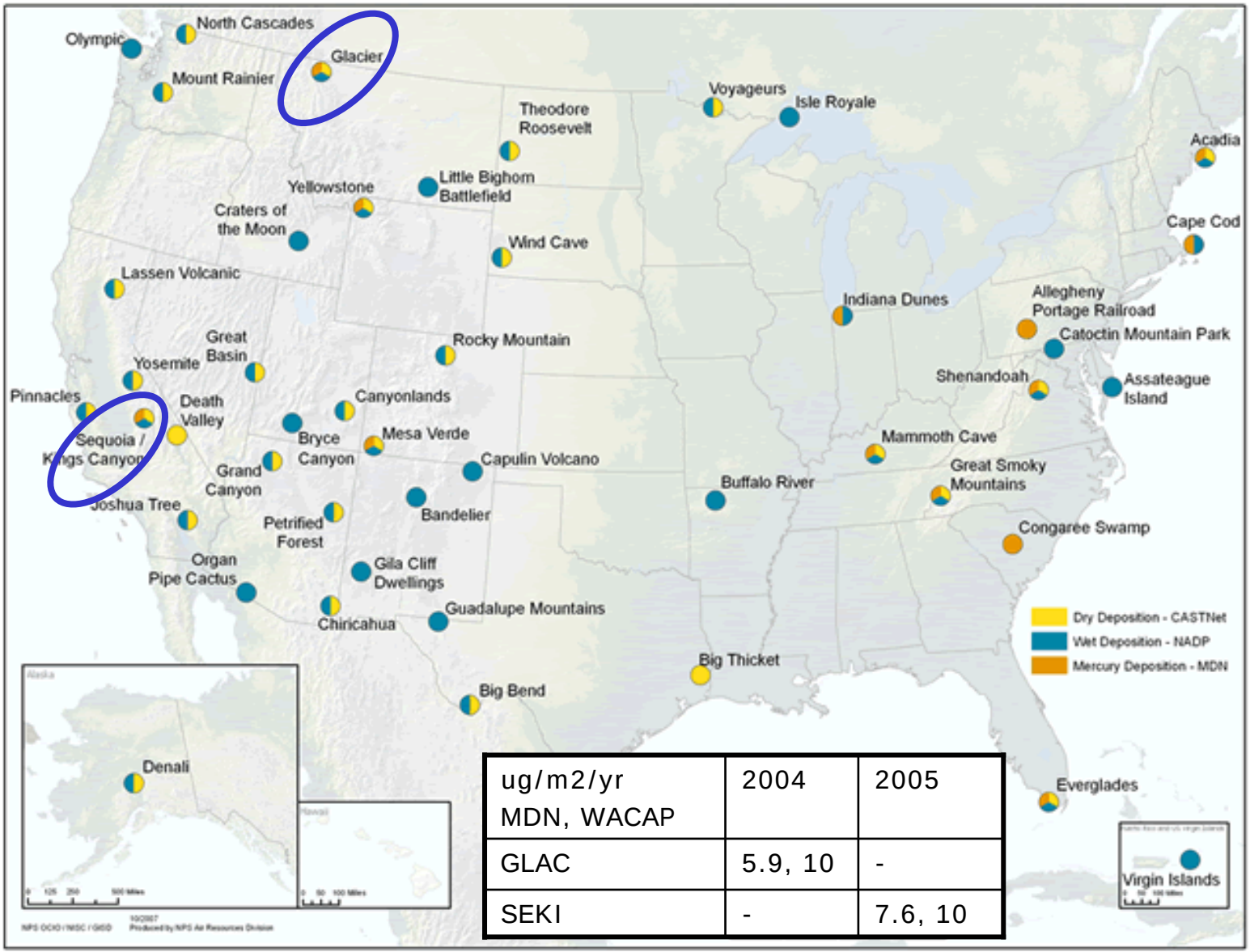

ug/m2/yr MDN, WACAP	2004	2005
GLAC	5.9, 10	-
SEKI	-	7.6, 10

Biological effects of Hg in Fish

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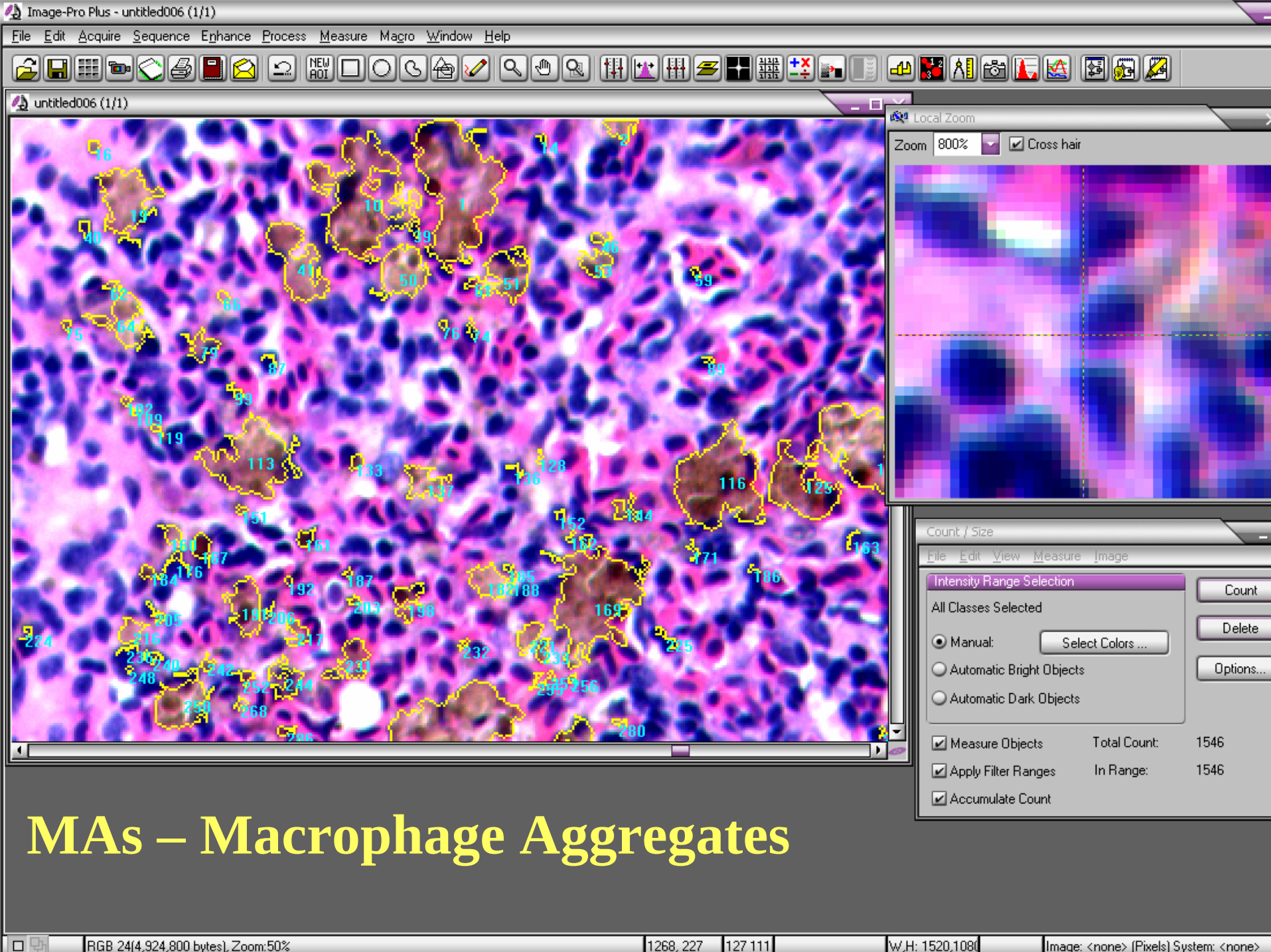
Increase in macrophage aggregates (MA's)

- MA's are a biomarker of exposure to Hg
- MA's increase with age = past exposure
- Hg increases with age = bio-accumulation

Schwindt et al. 2008. Mercury Concentrations in Salmonids from Western U.S. National Parks and Relationships with Age and Macrophage Aggregates. ES&T 42: 1365-1370.



MAs – Macrophage Aggregates

Mercury and Particulate carbon in snow

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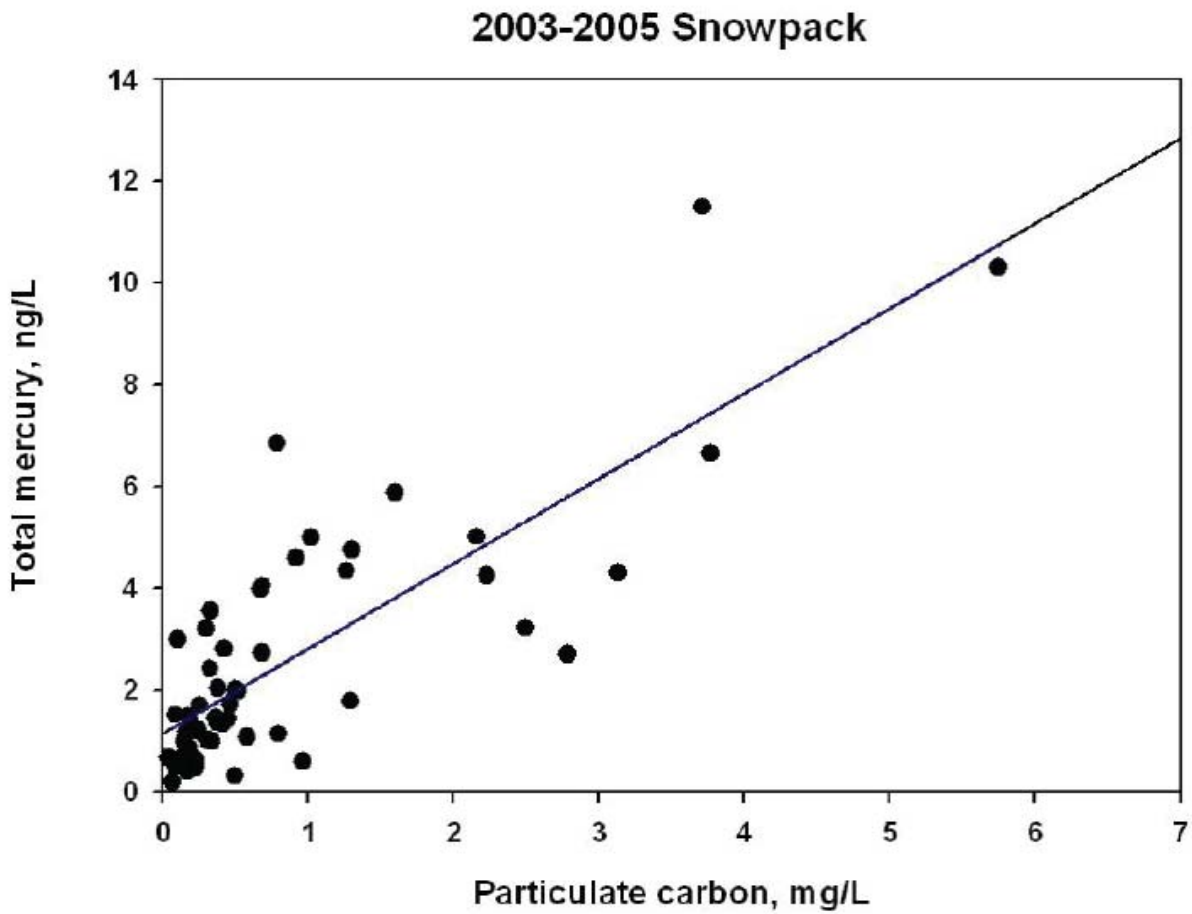
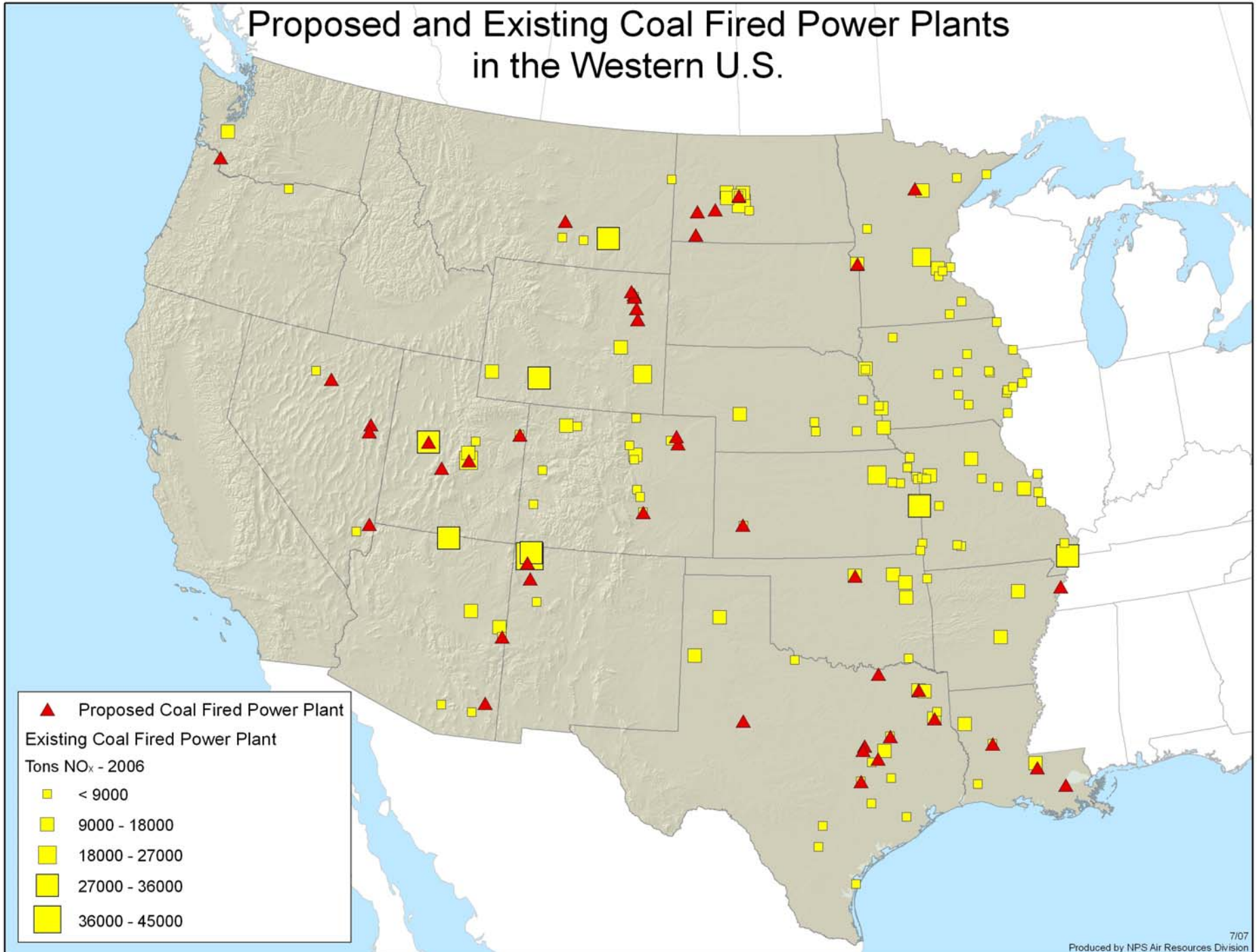
- Strong correlation ($R^2 = 0.63$, $p < .0001$) found between total mercury and particulate carbon concentrations in the snowpack
- Underlying mechanisms are uncertain



Proposed and Existing Coal Fired Power Plants in the Western U.S.

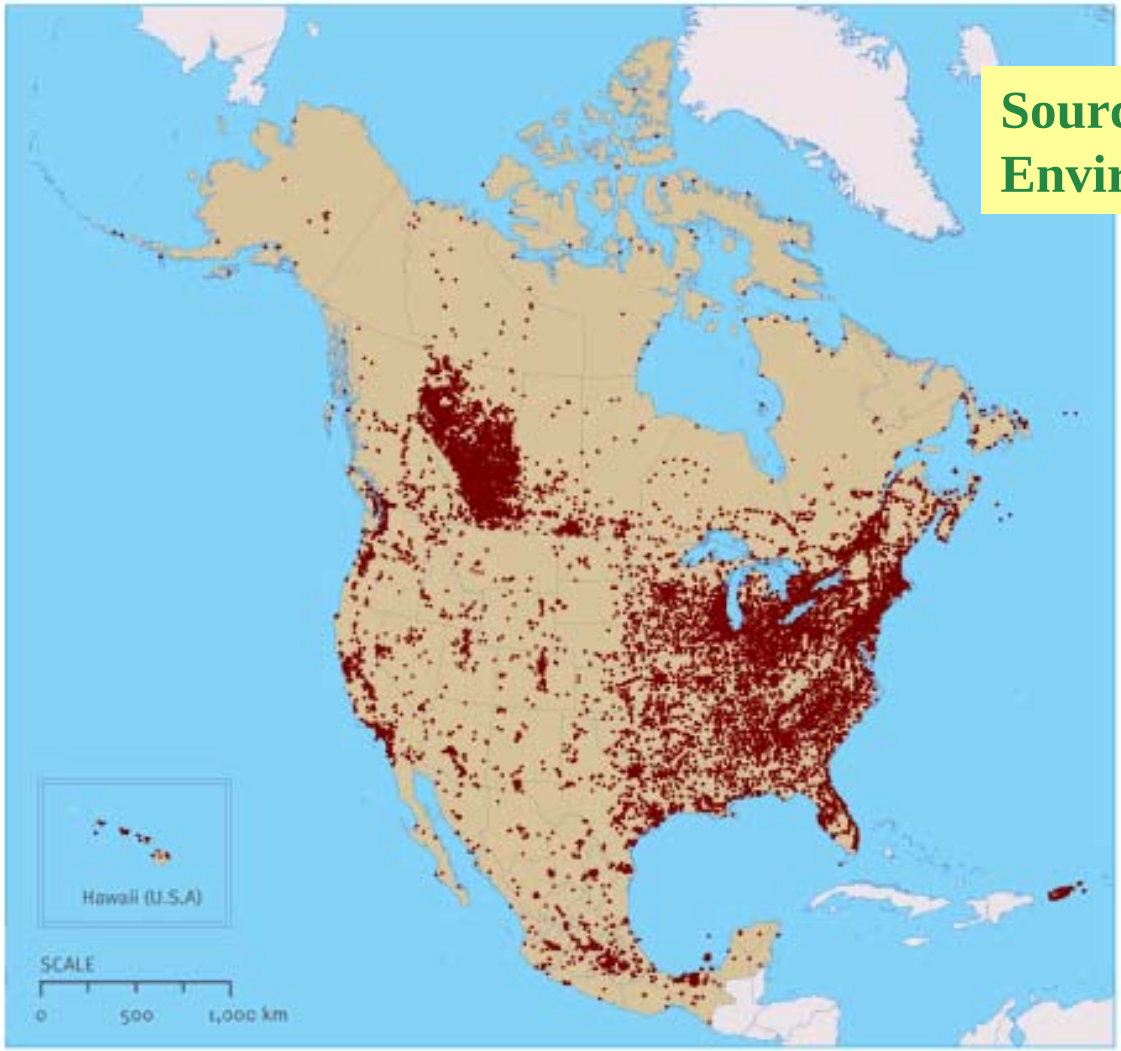


RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

WACAP

Industrial pollutants, 2004

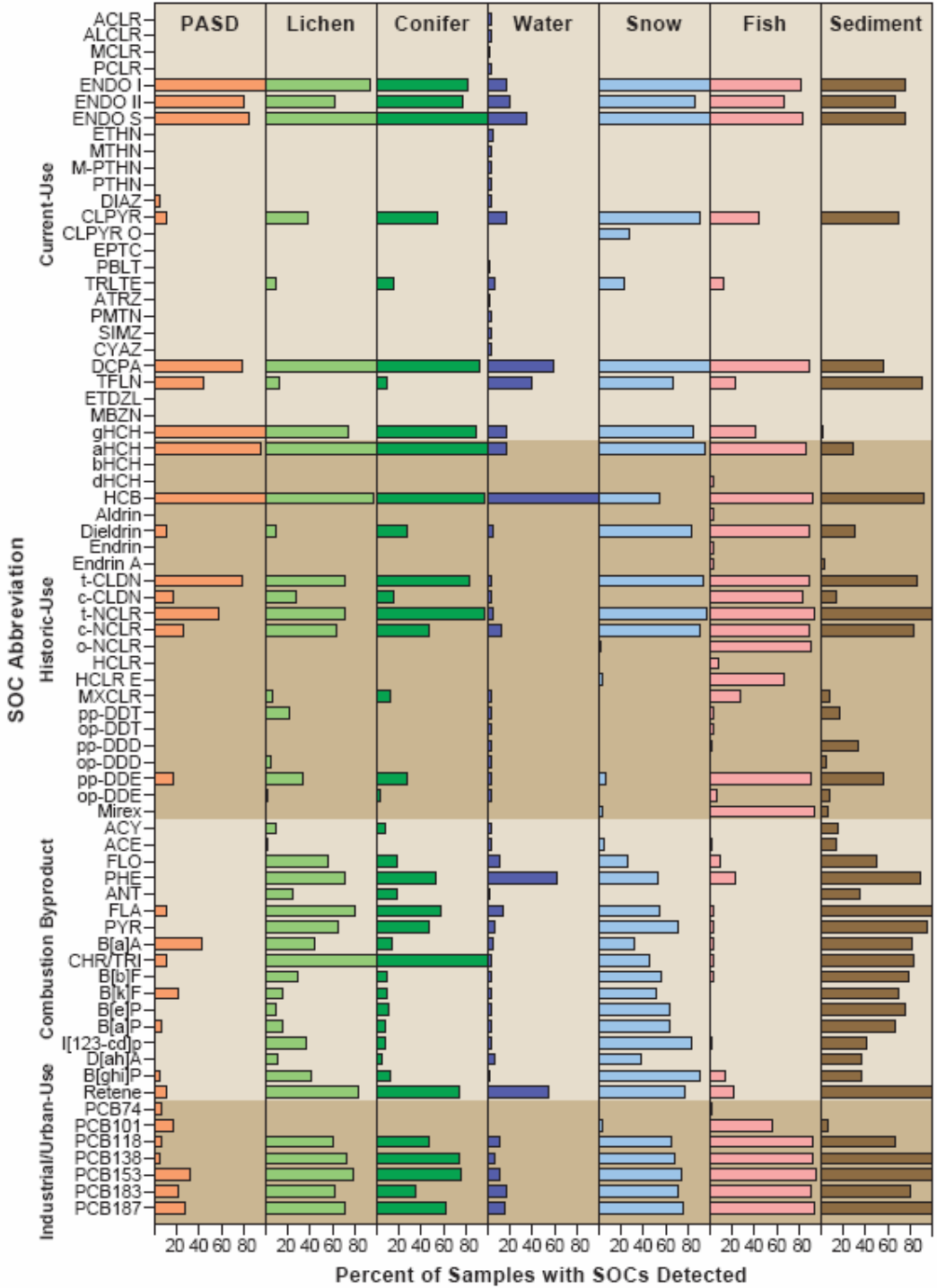


Source: North American Environmental Atlas

Description

This map shows the locations of almost 34,000 industrial facilities in North America that reported on releases or transfers of pollutants in 2004. Data for this map was assembled from each of the North American country's Pollutant Release and Transfer Registers (PRTRs): the National Pollutant Release Inventory (NPRI) in Canada, the Registro de Emisiones y Transferencias de Contaminantes (RETC) in Mexico, and the Toxics Release Inventory (TRI) in the United States.

- Out of over 100 SOCs tested, 70 were found at detectable levels in snow, water, vegetation, lake sediment, and/or fish in all 20 parks



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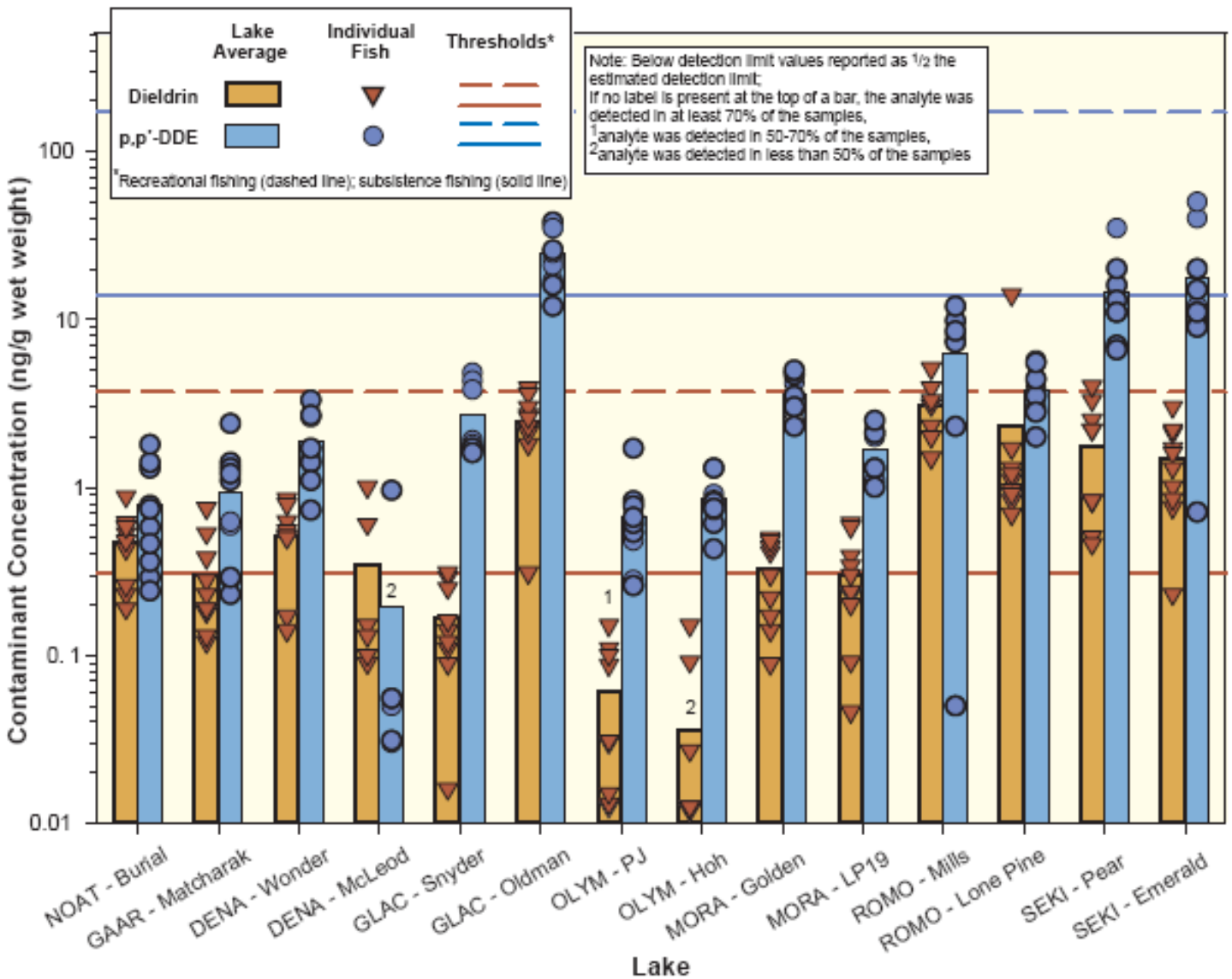
Pesticides (DDT, Dieldrin) in Fish



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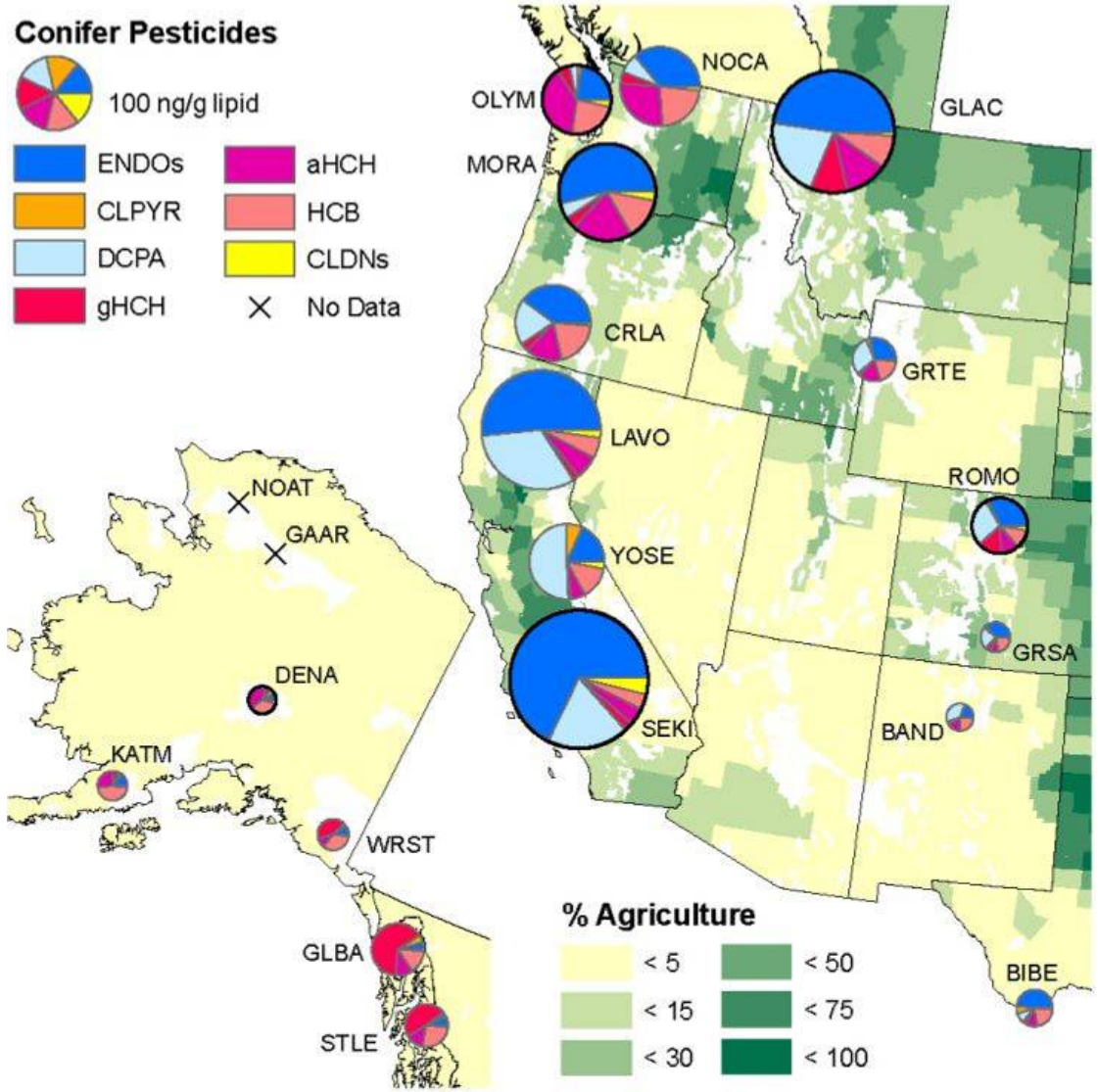
Contaminant Sources

- Parks nearest agricultural areas contained higher levels of pesticides
- Industrial contaminants (Hg and PAHs) highest in parks near local/regional point sources production



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Transport & Distribution

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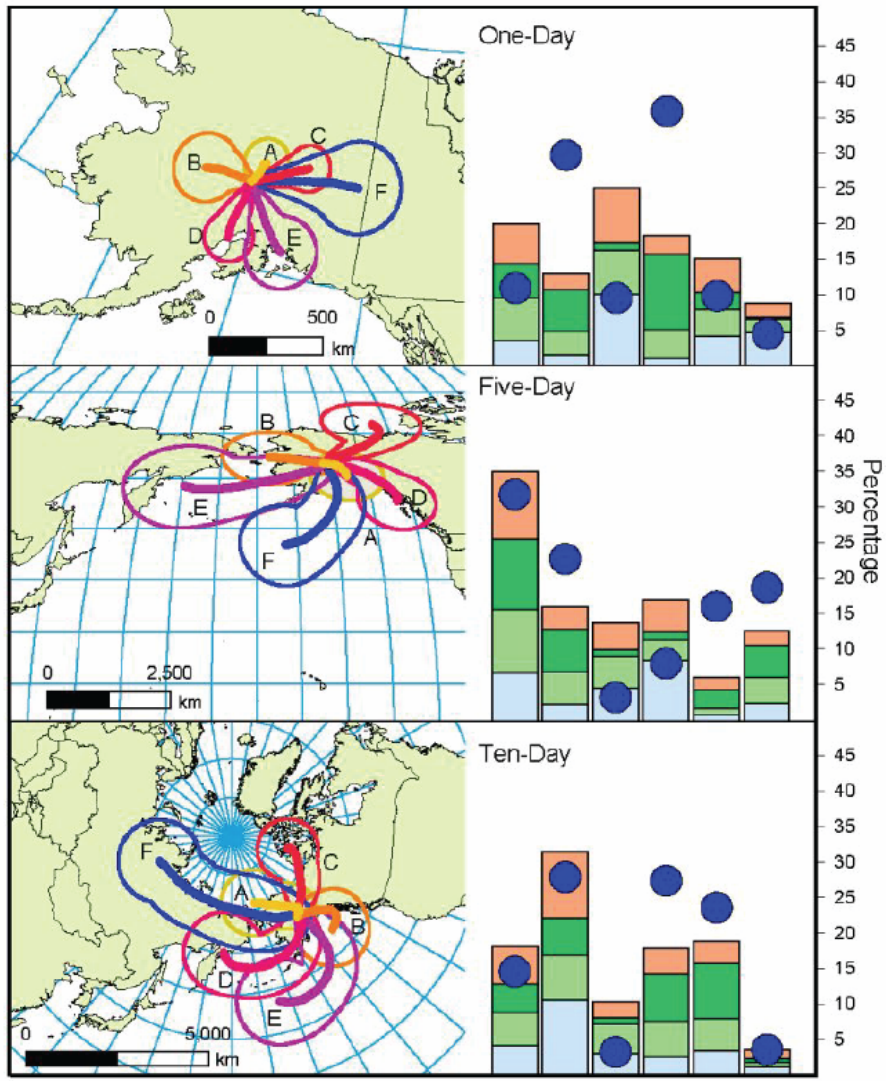
- Contaminant contributions from trans-Pacific sources were small in most parks compared to other sources closer to parks
  - Alaska parks an exception (e.g., Denali)
  - Indicated by back trajectory analysis and transport pathways



DENA